

National Aeronautics and Space Administration



Fermi

Gamma-ray Space Telescope

www.nasa.gov/fermi

Fermi

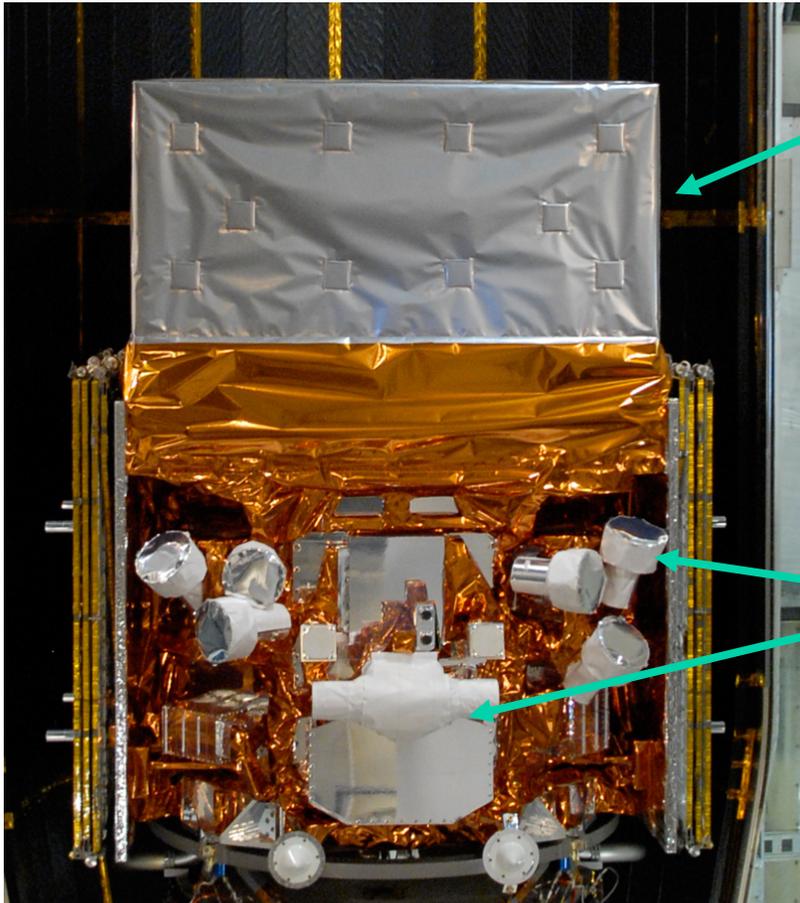
Gamma-ray Space Telescope

Data Analysis Workshop

Mission Overview

Elizabeth Hays on behalf of
the Fermi Mission Team

Fermi instruments



Large Area Telescope (LAT):

- 20 MeV - >300 GeV (including unexplored region 10-100 GeV)
- 2.4 sr FoV (scans entire sky every ~3hrs)

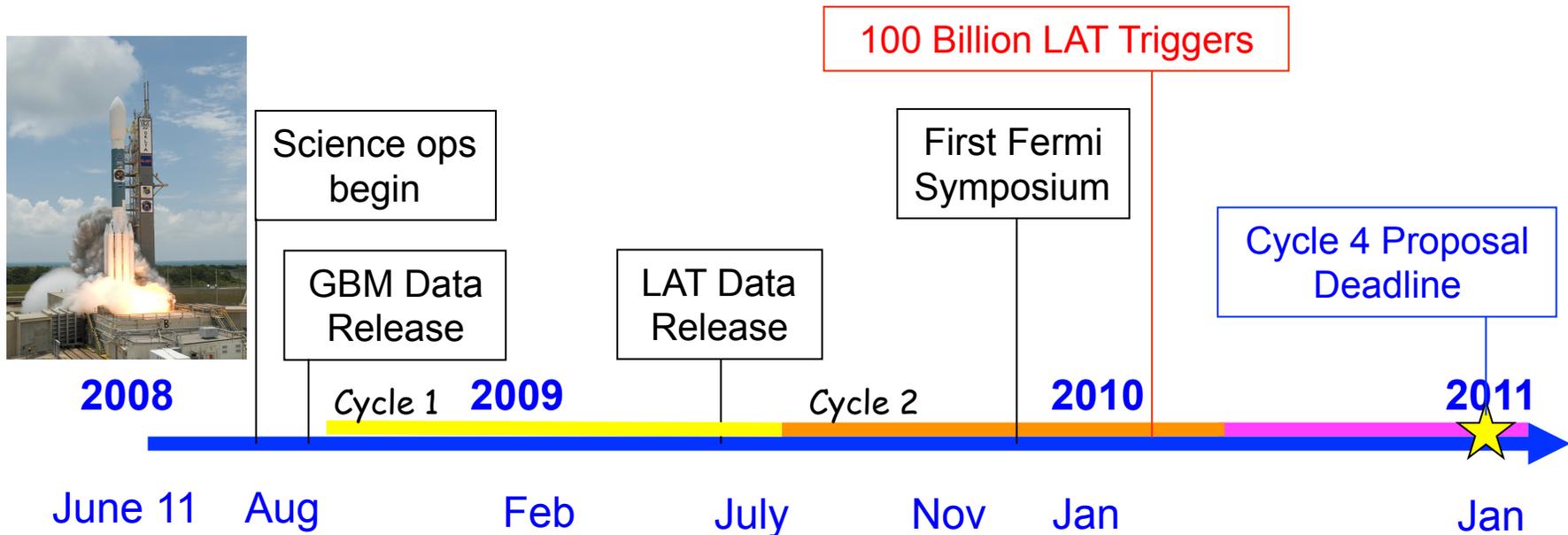
Gamma-ray Burst Monitor (GBM)

- 8 keV - 40 MeV
- views entire unocculted sky

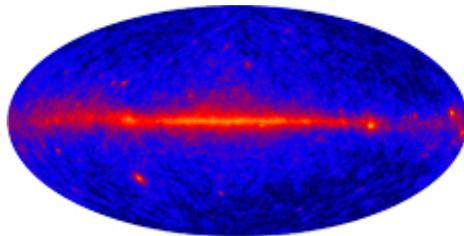
- **Large leap in all key capabilities, transforming our knowledge of the gamma-ray universe. Great discovery potential.**

Mission Milestones

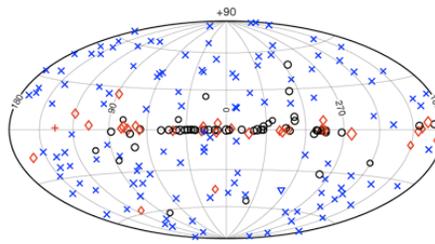
- Operations continue to be very smooth, thanks to an outstanding Flight Ops Team and great cooperation across the mission.



First Light

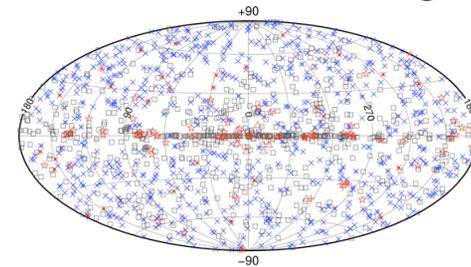


Bright Source List



○ Unassociated × AGN ◇ Pulsar
+ X-ray binary ▼ Globular cluster

First LAT Catalog



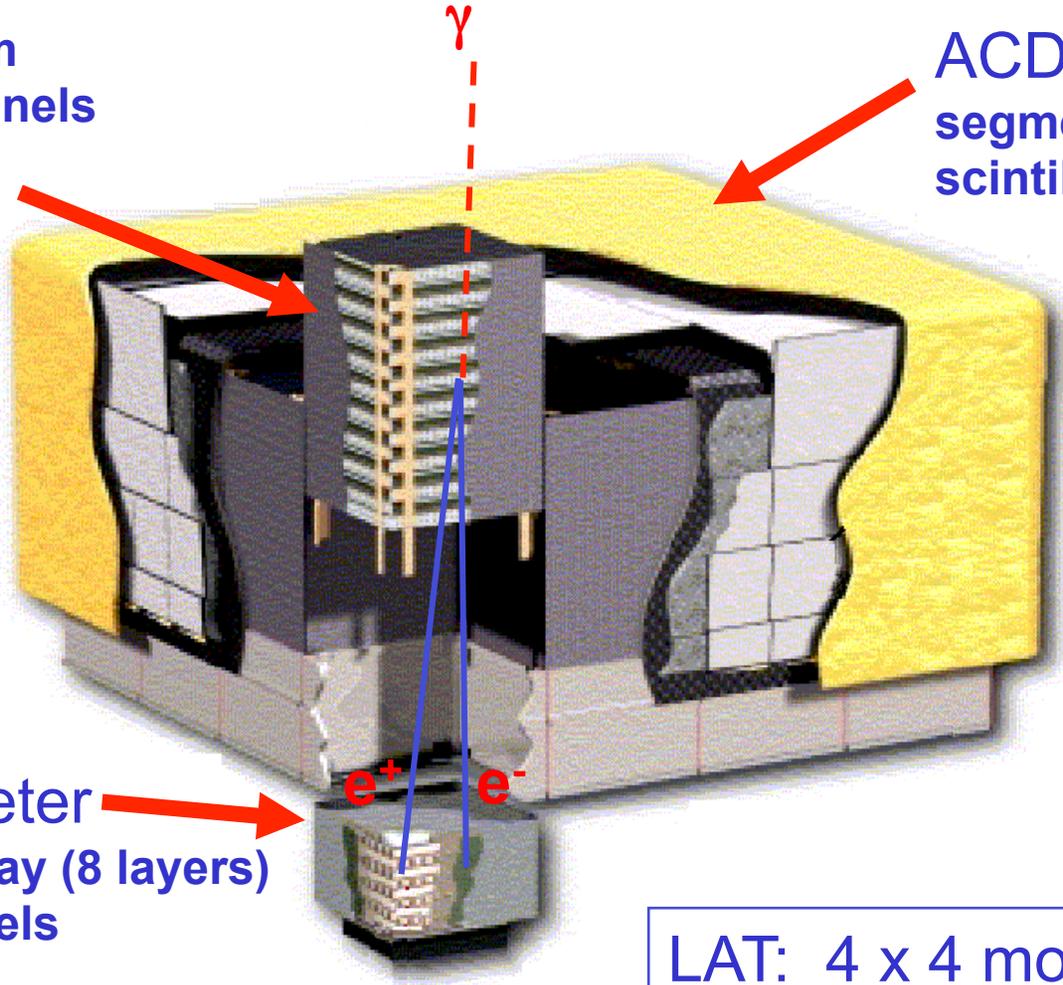
□ No association □ Possible association with nearby SNR or PWN
× AGN - blazar ★ Starburst Gal × Pulsar × Pulsar w/PWN
× AGN - unknown Galaxy ◇ PWN △ Globular cluster
× AGN - non blazar ○ SNR × XRB or MQO

The Large Area Telescope

Si Tracker

pitch = 228 μm
 8.8×10^5 channels
18 planes

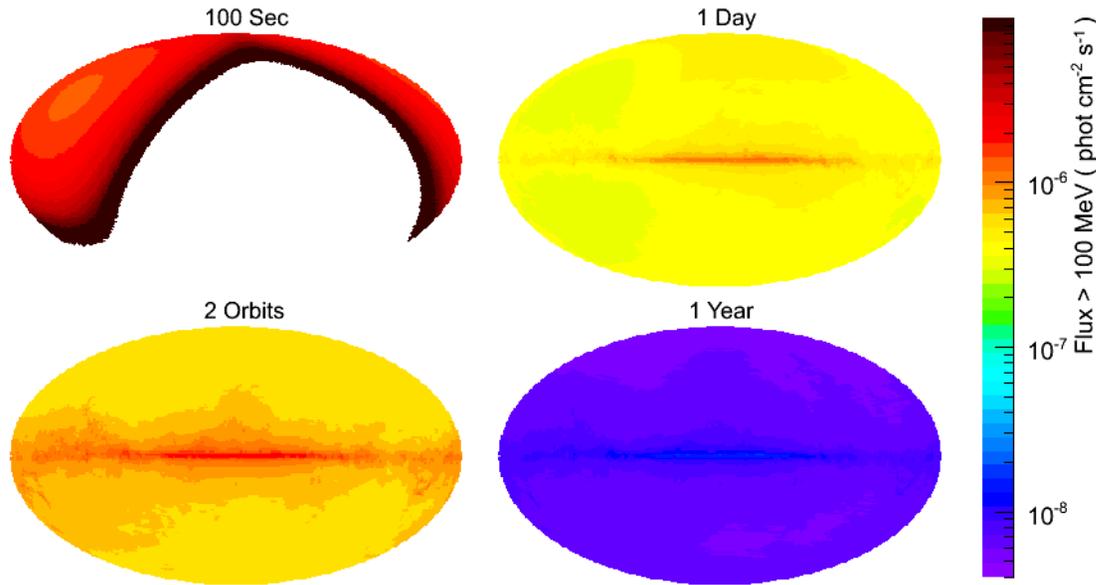
ACD
segmented
scintillator tiles



CsI Calorimeter
hodoscopic array (8 layers)
 6.1×10^3 channels

LAT: 4 x 4 modular array
3000 kg, 650 W
20 MeV – 300 GeV

Operations and observing modes



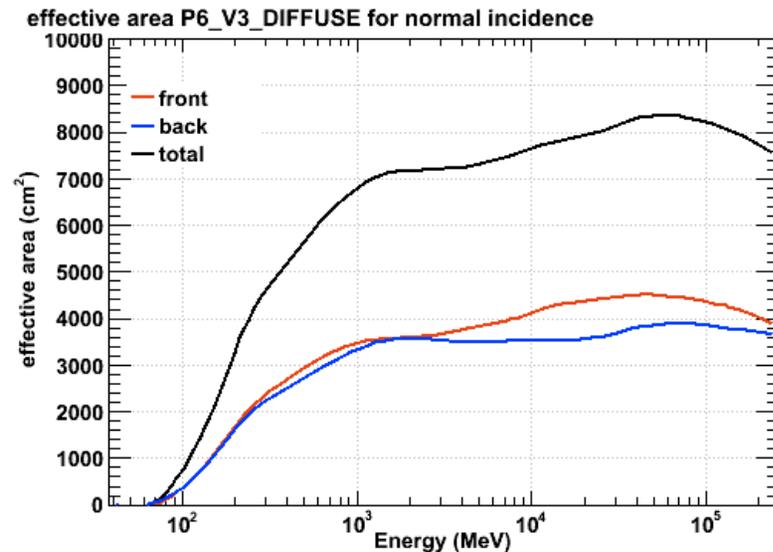
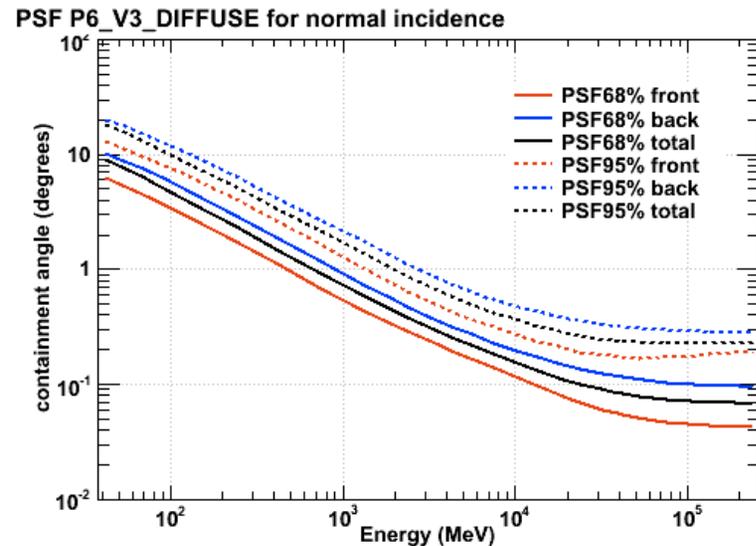
LAT sensitivity on 4 different timescales:

100 s, 2 orbits (2x96 mins), 1 day and 1 year

- **Almost all observations in survey mode - entire sky every two orbits (~3 hours), each point on the sky ~30 mins exposure**
 - **35 deg rocking angle to September 2, 50 deg rocking angle after**
- **>50 ARRAs - pointed mode observations of bright GBM detected GRBs**
 - **5 hr duration shortened to 2.5 hrs in November 2010**
- **2 ToOs - pointed mode observations toward a specified target**
 - **200 ks on 3C454.3 (Apr. 5, 2010), 360 ks on Crab (Sept. 23, 2010)**
- **LAT Calibrations (~20 hours), Engineering (5 days)**
 - **Very high ontime!**

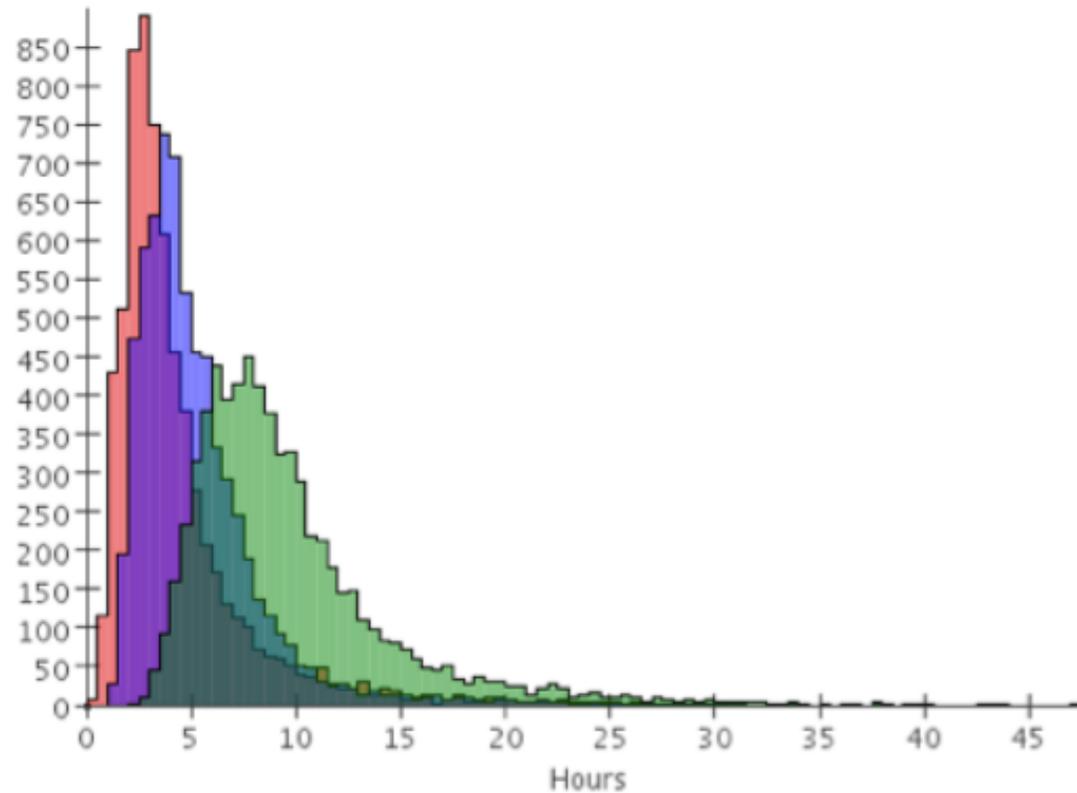
LAT Performance

- **Current response functions:**
Pass 6 V3
 - updated post-launch to include on-orbit, rate-dependent inefficiency
- **Point spread function**
 - **Very energy dependent**
 - **Little variation over FOV**
- **Effective Area**
 - **Peak >8000 cm² on-axis**
 - **Increases rapidly 100 MeV to 200 MeV**
 - **Plateaus above ~1 GeV**
- **Energy dispersion**
 - **E/E < 0.15 (68% containment)**
 - **Small compared to energy range**



<http://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone/Cicerone_LAT_IRFs/>

LAT Data Latency

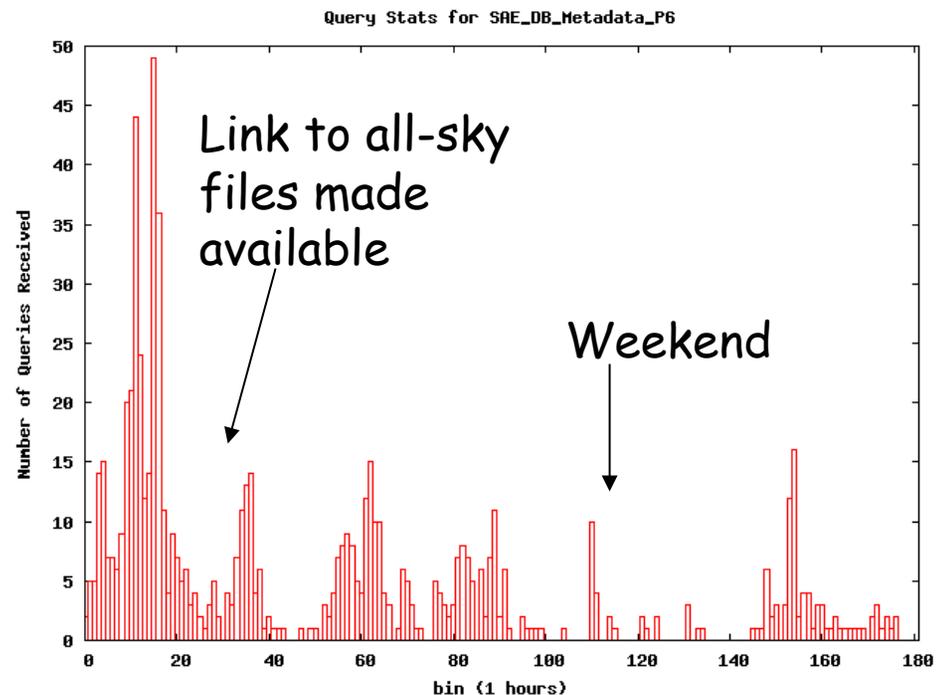


- **Typical turnaround is less than 10 hours (time to get data off spacecraft, processed and back to FSSC)**

Software and Data Releases

- **Beginning of science operations: GBM data + LAT high level data from start of science operations**
- **Feb 6, 2009: LAT bright source list, first Science Tools release**
- **Aug 25, 2009: LAT photon data, Science Tools release**
- **Sept 8, 2010: Science Tools Release**
- **Nov 17, 2010: Fermi Science Tools + LAT Pass 6 DataClean selection released**

- **~400 queries in first day, many requesting the entire dataset.**
- **Made link to weekly all-sky files more obvious (so number of queries dropped)**



LAT High Level Data Releases

The LAT team releases flux/spectra as a function of time for all sources in a pre-defined list + flaring sources during flares.

- Modified data release after ~6 months:

- Lower flux threshold (by 2x) to release information on flaring sources.

- Provide information continuously (not just during flares).

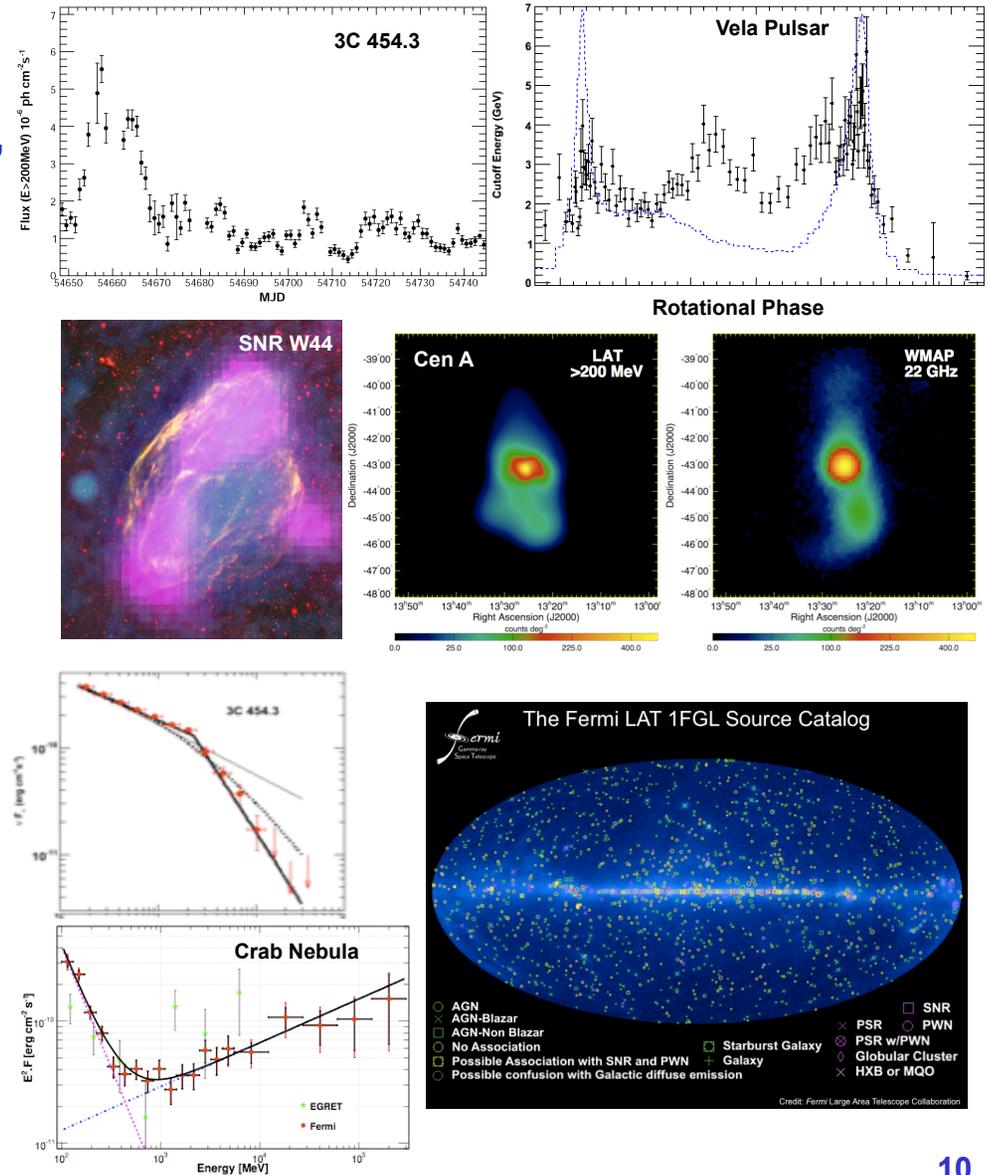
- Originally 23 sources, now >50!

- <http://fermisky.blogspot.com>

Source Type	Source Name	EGRET Name	Average or Min. Flux ($10^{-8} \gamma \text{ cm}^{-2} \text{ s}^{-1}$)	Galactic Latitude	Redshift	TeV Source
Blazar	0208-512	3EGJ0210-5055	85.5 ± 4.5	-61.9	1.003	
	0235+164	3EGJ0237+1635	65.1 ± 8.8	-39.1	0.94	
	PKS 0528+134	3EGJ0530+1323	93.5 ± 3.6	-11.1	2.060	
	PKS 0716+714	3EGJ0721+7120	17.8 ± 2.0	28	0.3	
	0827+243	3EGJ0829+2413	24.9 ± 3.9	31.7	0.939	
	OJ 287	3EGJ0853+1941	10.6 ± 3.0	35.8	0.306	
	Mrk 421	3EGJ1104+3809	13.9 ± 1.8	65.0	0.031	Yes
	W Com 1219+285	3EGJ1222+2841	11.5 ± 1.8	83.5	0.102	
	3C 273	3EGJ1229+0210	15.4 ± 1.8	64.5	0.158	
	3C 279	3EGJ1255-0549	74.2 ± 2.8	57.0	0.538	
	1406-076	3EGJ1409-0745	27.4 ± 2.8	50.3	1.494	
	H 1426+428	NA		64.9	0.129	Yes
	1510-089	3EGJ1512-0849	18.0 ± 3.8	40.1	0.36	
	PKS 1622-297	3EGJ1625-2955	47.4 ± 3.7	13.4	0.815	
	1633+383	3EGJ1635+3813	58.4 ± 5.2	42.3	1.814	
	Mrk 501	NA		38.9	0.033	Yes
	1730-130 NRAO 530	3EGJ1733-1313	36.1 ± 3.4	10.6	0.902	
	1ES 1959+650	NA		17.7	0.048	Yes
	PKS 2155-304	3EGJ2158-3023	13.2 ± 3.2	-52.2	0.116	Yes
	BL_Lacertae (2200+420)	3EGJ2202+4217	39.9 ± 11.6	-10.4	0.069	Yes
3C 454.3	3EGJ2254+1601	53.7 ± 4.0	-38.3	0.859		
1ES 2344+514	NA		-9.9	0.044	Yes	
HMXB	LSI+61 303 2CG135+01	3EGJ0241+6103	69.3 ± 6.1	1.0		Yes

LAT Science - Very Broad!

- **Transients and Variability**
 - >18 LAT GRBs, flaring AGN, X-ray binaries and microquasars, unidentified flares
 - Solar flares
- **Pulsars**
 - Discovery, timing, phase profile and spectral studies
- **Imaging**
 - Resolving large supernova remnants and nearby galaxies
- **Catalogs**
 - Identifying LAT sources through spatial, spectral and timing features
 - Characterizing gamma-ray populations
- **Diffuse emission and cosmic rays**
- **Dark matter and new physics searches**



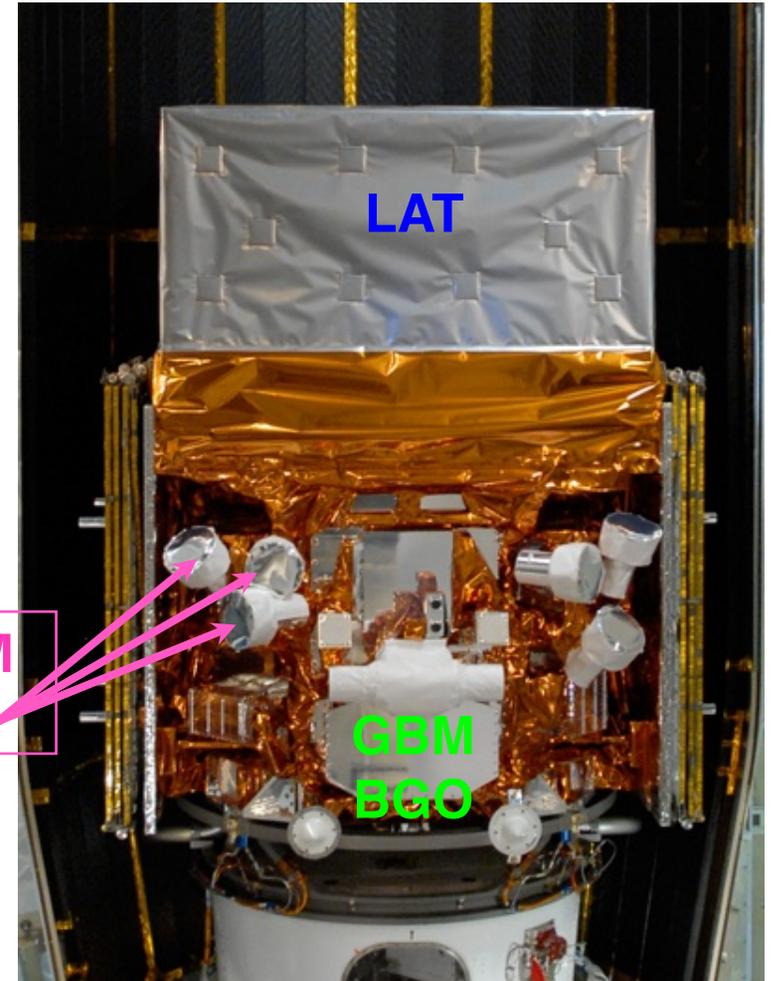
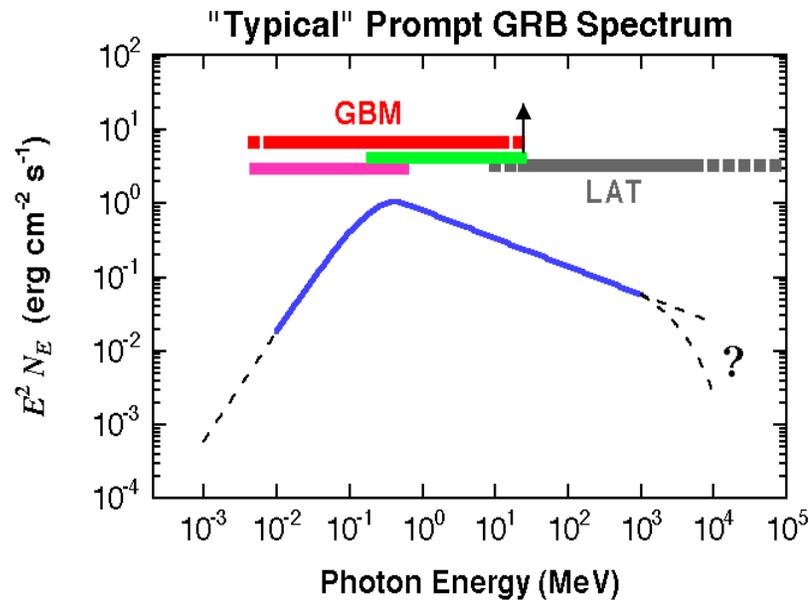
Gamma-ray Burst Monitor

Fermi GBM views entire unocculted sky

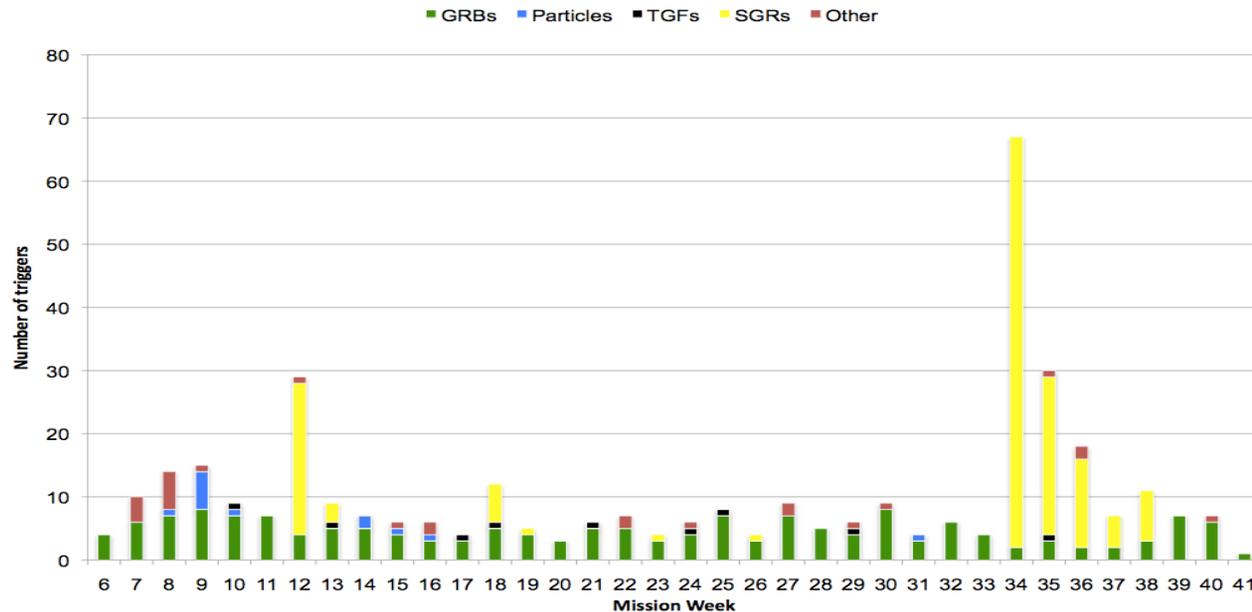
NaI: 8 keV - 1 MeV

BGO: 200 keV - 40 MeV

- Fermi GBM + LAT covers >7 decades in energy (8 keV to > 300 GeV)
- Both LAT and GBM can independently trigger



GBM triggers by week



USA (MSFC, UAH,
LANL) and
Germany (MPE)

PI - Bill Paciesas (UAH)

Co-PI - Jochen Greiner
(MPE)

- **GBM has detected over 500 GRB (250/year c.f. 200/year predicted)**
 - **Benefited from flexible onboard triggering algorithms**
- **Also SGRs, terrestrial gamma-ray flashes and solar flares.**
- **Fall 2009 flight software updates improved reliability of autonomous repoint requests (more reliably points LAT to only bright GRB)**
- **Summer 2010 improvements to increase detection of TGFs**

GBM - not just transients

GBM Pulsar Project

http://gammaray.nsstc.nasa.gov/gbm/science/pulsa

Most Visited Getting Started Latest Headlines

GBM Pulsars

Source Name	lii (deg)	bii (deg)
GX 1+4	1.94	4.79
Her X-1	58.20	37.50
Cep X-4	99.01	3.31
EXO 2030+375	77.15	-1.24
V 0332+53	146.05	-2.19
A 0535+26	181.50	-2.64
MXB 0656-072	220.20	-1.76
Vela X-1	263.06	3.90
Swift J0513.4-6547	275.99	-34.55
GRO J1008-57	283.00	-1.80
A 1118-615	292.50	-0.90
Cen X-3	292.10	0.30
GX 301-2	300.10	-0.04
4U 1626-67	321.79	-13.09
4U 1538-52	327.42	2.16
OAO 1657-415	344.40	0.31

GBM Accreting Pulsar Histories

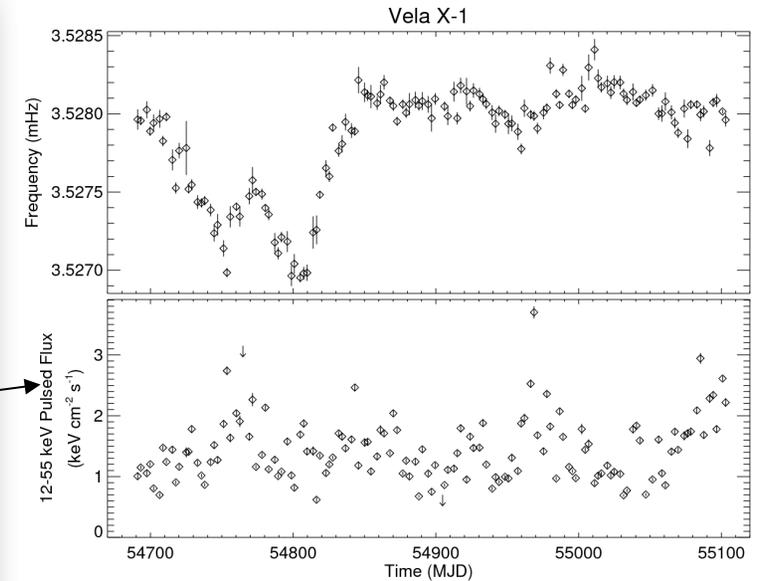
For each source we plot the history of pulse frequency and pulsed flux measured using the Fermi Gamma-Ray Burst Monitor (GBM) NaI detectors. For these measurements we use the CTIME data which normally has 0.256 s time bins, and eight energy channels. Our analysis normally uses channels 1 (12-25 keV) and 2 (25-55 keV). The integration intervals used varies from source to source, ranging from one to four days. For eclipsing systems each egress to ingress interval is divide into an integral number of equal parts, with no measurement made during the eclipse. The measured frequencies are barycentered. For sources where the binary orbit is known the frequencies are corrected for the binary motion. The R.M.S. pulsed flux is given in the energy band that the pulse search was made. This usually includes only the first and second harmonics. These results are preliminary. Please contact [Mark Finger](#) for further information.

Please return to [GBM Science](#) or [the GLAST Burst Monitor](#) or [the Gamma Ray Astrophysics Home Page](#).

Modification date: 06 Jul, 2009

Author [Valerie Connaughton](#)

http://gammaray.nsstc.nasa.gov/gbm/science/pulsars/lightcurves/velax1_fig1.png



GBM team have made non-GRB high level data/results available.

Available on the FSSC website



Conclusions

- **Fermi observatory and instruments are operating very well**
- **Extremely broad science capabilities and many opportunities to contribute**
- **Variety of public data products available**
- **Lots of great science to come!**

[**<fermi.gsfc.nasa.gov>**](http://fermi.gsfc.nasa.gov)